The Effects of Training Blind Students in Distinctive Features Analysis and Line Tracing on Tactile Shape Recognition and the Location of Shapes on a Tactile Map

Edward P. Berla', Lawrence H. Butterfield, Jr., and Marvin J. Murr
American Printing House for the Blind

Professional Library
American Printing House for the Blind
Louisville, Kentucky

Running head: Distinctive Features and Line Tracing

Abstract

Two experiments were conducted to determine the effects of training blind students in using a distinctive features analysis strategy and line tracing on shape recognition accuracy and speed and accuracy of locating shapes on a tactile map. In Experiment I, training improved the shape recognition performance of a group of 25 trained braille readers by 32% as compared to a matched group of 25 untrained braille readers. In Experiment II, training resulted in a 25% increase in the number of shapes located and a 41% decrease in the average time to locate a shape on a tactile map by 21 trained students as compared to a matched group of 21 untrained students. The results are discussed in terms of the critical importance of training blind students to be analytical, systematic, and complete in exploring tactile materials to ensure adequate development of perceptual-conceptual abilities.

The Effects of Training Blind Students in Distinctive Features Analysis and Line Tracing on Tactile Shape Recognition and the Location of Shapes on a Tactile Map

In a series of studies investigating the effects of stimulus parameters and methods of exploring shapes (Berla', 1972; Berla', 1974; Berla' & Murr, Note 1) it was found that tactual shape discrimination performance was quite poor by children in grades 1-6. There were three striking observations concerning the blind child's inspection of tactile shapes. First, it was observed that many of the children failed to completely explore the entire tactile shape and many inspected only a small portion of a shape. Secondly, the overwhelming majority of the students had no systematic method for exploring shapes. Third, some subjects did trace the entire shape, but did not appear to realize at what point on the shape they had begun tracing and at what point on the shape they had completed their tracing. In other words, they failed to determine a point of origin and a point of ending.

In other studies (Berla', 1973; Berla' & Murr, 1974; Berla' & Murr, in press; Berla', Butterfield, & Murr, in press; Nolan & Morris, 1971) on tactile map reading by blind students in grades 4-12, it was found that students are unsystematic in their exploration of maps. In a videomatic study (Berla', Butterfield, & Murr, in press) of blind students reading tactile political maps it was found that poor map readers have substantial difficulty in tracing lines. They have a tendency to fall off the line they are tracing and/or are disrupted by other intersecting lines. Good map readers have no difficulty in tracing the outlines of bounded areas on maps. Furthermore, a major characteristic of the performance of good map readers is the degree to which they appear to perform a distinctive features analysis of shapes either in inspecting a shape in isolation or locating it on a map. Poor map readers engage in a distinctive features analysis less frequently and less skillfully than good map readers.

In summary, three perceptual-cognitive deficits have permeated the tactual-motor performance of blind students:

1. Lack of a systematic method of exploring tactual materials; students not only perform in an unsystematic manner, but also appear to have no knowledge of what a system is or the importance of being systematic in their exploration of their tactile environment.
2. Poor line tracing skills.
3. Lack of an analytic cognitive strategy in exploring tactile materials, such as a distinctive features analysis of shapes which Gibson (1969) has shown to be of critical importance in the development of various perceptual abilities.

The present studies focused on training in two basic skills: distinctive features analysis of shapes and line tracing. In concentrating on these two skills a third derived skill is implicitly being taught, and that is a systematic exploration of the tactile environment.

In the first experiment, students were trained in line tracing and distinctive features analysis to determine if it would improve their shape recognition accuracy. In the second experiment the same type of training was used to determine if it would improve the speed and accuracy with which shapes were located and traced on maps.

Experiment I

Method

Subjects. The subjects were 50 students enrolled in residential schools for the blind who used braille as their primary reading medium. The number of students participating from grade classifications of beginners, primary, and grades 1-5 were respectively: 3, 18, 6, 10, 6, 6, 1. There were 31 males and 19 female students. The mean, SD, and range of their ages in years were as follows: $M = 9.69$, $SD = 2.14$, range = 5.92-16.92. The schools participating in the research were the Alabama Institute for the Deaf and the Blind, the Louisiana State School for the Blind, and the Overbrook School for the Blind.

Materials. The pretest and posttest materials were exactly the same and consisted of a series of 36 shape recognition cards. On one side of a card there was a single standard shape and on the flip side there were four shapes which consisted of the standard and three choices. The shapes consisted of two sets of outline figures drawn from 18 United States' states and 18 European countries. Each shape appeared once as the standard, and the choice figures were chosen from the same set from which the standard was chosen. The states and countries were traced on paper from maps which appeared in: Goode's World Atlas (Espenshade & Morrison, 1974), National Geographic Atlas of the World (National Geographic Society, 1970), and Reader's Digest Great World Atlas (Reader's Digest Association, 1963). All the shapes were photographically reduced or enlarged to fit within the confines of a 3-inch circle. Photographs of the shapes were used in a photo-etching process to make raised line figures on metal plates. Vacuum-formed plastic copies were made of each of the shapes and the plastic copies were mounted on rectangular sheets of cardboard measuring 19.05 X 41.91 cm. The height of the raised lines was .076 cm and the width was .12 cm. The shapes were centered and equally spaced on the cards.

The choice figures for each standard were chosen on the basis of similarity in shape. Each shape appeared an equal number of times as choice figures on the pre- and posttests with the standard (correct alternative) appearing in each of the four choice positions an equal number of times. A different random order of presentation of the 36 cards was used for the pre- and posttests. The pretest consisted of the 36 shapes presented in their correct orientation. The posttest consisted of the same standards and choice figures but rotated 180° from their orientation on the pretest. The United States' states and European countries used on these tests were: Alabama, Idaho, Indiana, Kentucky, Maine, Minnesota, Missouri, Nevada, New Mexico, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, Utah, West Virginia, Wisconsin, Wyoming; Albania, Austria, Belgium, Bulgaria, Czechoslovakia, East Germany, Finland, France, Ireland, Italy, Netherlands, Poland, Portugal, Romania, Spain, Sweden, Switzerland, West Germany.

The training materials consisted of 27 shape recognition cards using countries in Africa, Asia, and South America. The countries chosen were: Botswania, Central African Republic, Chad, Ethiopa, Guinea, Libya, Mali, Somalia, Southwest Africa, Sudan; Afghanistan, Cambodia, Iran, Iraq, Laos, Mongolia, Nepal, North Korea, Pakistan, Syria, Yemen; Brazil, Colombia, Ecuador, Paraguay, Venezuela. Outline figures of each of these countries were taken from maps which appeared in the atlases previously cited. The tactile shapes were constructed in the same manner as the materials used on the pre- and posttests.

Design and procedure. The students were told that they were going to play a game in which they would be shown a card which had a shape on it. They were told to feel the shape for 30 seconds after which they would be shown four shapes from which they were to identify the shape they had felt before. All students were then shown a card which had a triangle on one side and a circle, square, rectangle, and triangle on the flip side. The students felt the triangle and then the card was flipped over and the students were asked to choose the correct shape. All the students were then given the pretest. Those who got 8 (78% correct) or more wrong were designated as the target population. Once the target population had been identified the subjects were matched in pairs on their pretest scores first and then their grade level. One member of each pair was randomly assigned to the trained group and the remaining student was assigned to the untrained group. The students in the trained group were instructed to trace a shape by using the index finger of their preferred hand while using the index finger of the non-preferred hand as a reference. Tracing was to begin and end at the reference finger.

After tracing the contour, subjects were instructed to trace the shape again and pick out three distinctive features. Distinctive features were defined as "parts that stick out, parts that are pointed, parts that go in, parts that are curved." Each subject was asked to tap the parts chosen and tell the experimenter. The subject was then asked to trace the shape again to "make sure you know what the shape is like." The card was then flipped over and the subject was told to find the same shape by finding the shape that had the same parts as the shape he had traced before. If the student located the correct shape he was asked to trace it and show the experimenter the parts he had picked out before. If the student picked the wrong shape he was shown the standard shape again and the entire instructional process was repeated. If the student failed to recognize the target shape again the experimenter placed the student's finger on one of the distinctive features the student had picked out and the student was told to trace the shape and show the three parts he had picked out before. If the student forgot what parts he had chosen or picked parts that were different from the original set of three, the experimenter placed the student's finger on each of the chosen parts. The student was then asked to trace the shape again and show the experimenter the three parts. Throughout a training session the student was given assistance in line tracing and reminded on each trial to trace the shape, pick out three parts that were different, and trace the shape again.

Each student was trained in three sessions over 3 consecutive days. Each subject was given 30 minutes for the entire training session. A session consisted of nine shape recognition trials. If a subject completed the nine trials in less than 30 minutes, the cards were rotated 180° and the subject was given up to nine additional trials. At the completion of training, both the trained and untrained subjects were posttested. Both the pretest and posttest required approximately 35 minutes to administer.

Results

The data consisted of the percentage of correct responses. Since subjects were matched on their pretest scores and then randomly assigned to either the trained or untrained groups, the group's factor was considered as a within subjects variable. A two-factor repeated measures analysis of variance was performed on the data with the factors being pretest vs. posttest and trained vs. untrained. The analysis showed significant main effects for the trained vs. untrained groups ($\underline{F} = 21.20$; $\underline{df} = 1, 24$; $\underline{p} < .01$) and pretest vs. posttest ($\underline{F} = 6.54$; $\underline{df} = 1, 24$; $\underline{p} < .05$). The interaction of the trained vs. untrained groups x pretest vs. posttest was also significant ($\underline{F} = 27.66$; $\underline{df} = 1, 24$; $\underline{p} < .01$). A summary of the analysis of variance is shown in Table 1.

Insert Table 1 about here

A summary of the means and standard deviations of the percentage of correct recognitions for the trained and untrained groups on the pretest and posttest is shown in Table 2. Inspection of Table 2 shows that the matching of the subjects on the pretest resulted in nearly identical means and standard deviations. On the posttest the untrained group showed a very small decrease in performance while the trained group showed a relative increase in the percentage of correct recognitions of 27% from pretest to posttest. The trained group scored 32% higher relative to the untrained group on the posttest. Of the 25 subjects in the untrained group; 8 (32%) showed an increase from pre- to posttest, 12 (48%) showed a decrease, and 5 (20%) remained the same. Of the 25 subjects in the trained group; 21 (84%) showed an increase from pre- to posttest, one (4%) showed a decrease, and three (12%) remained the same. As is usually observed in most training programs, some students benefited more from training than other students. One trained student, for example, went from 31% correct on the pretest to 78% correct on the posttest.

Insert Table 2 about here

Summary and discussion

A short period of instruction in line tracing and distinctive features analysis significantly improved the shape recognition performance of blind students. On an absolute basis, however, performance on the posttest by the trained subjects was far below an acceptable level from an educational achievement standpoint. However, the shapes were very similar and quite complex and the total amount of training time was of relatively short duration. In essence it is a difficult task for young blind students. At the very least, this study demonstrates that training and emphasis on just these skills and concepts is an effective way of improving the tactual perceptual performance of young blind students.

It was observed during the posttest that a few of the trained students abandoned in part or entirely the techniques taught during the training period. This, of course, attenuated improvements in performance. Presumable with longer training periods and practice the students would begin to develop more skill and adopt and use these skills spontaneously in engaging in various tactual tasks. Consequently, performance should improve substantially with longer training periods.

Experiment II

This experiment focused on training in line tracing and distinctive features analysis to determine whether it would improve blind students speed and accuracy of locating and tracing shapes on a tactile political map. In this study all the students were pretested on their accuracy and speed of locating each of eight different bounded areas (shapes) on a map. On the basis of their pretest scores the subjects were matched in pairs. One member of each pair was randomly selected and trained in three 1/2-hour sessions over 3 consecutive days in line tracing and distinctive features analysis and then was given practice in locating shapes on maps. Following training both the trained and untrained groups were posttested.

Method

Subjects. The subjects were 42 students from the W. Ross Macdonald School in Ontario, Canada, who used braille as their primary reading medium. There were an equal number of males and females randomly selected from grades 2-7. The number of students selected from each of grades 2-7 were respectively: 1, 6, 7, 8, 15, 4, and one student from an ungraded class. The mean, standard deviation, and range of ages of the students in years were; M = 11.88, SD = 1.84, range = 8.42-15.08.

Test materials. Pretest and posttest map: A pseudomap was constructed using a thin raised line. The content of the map consisted of eight states of the United States and were as follows: Alabama, Idaho, Illinois, Maine, Missouri, Oklahoma, Pennsylvania, Wisconsin. Each state was photographically reduced or enlarged to fit within the confines of a 3-inch circle.

A 22.86 X 33.02 cm page was divided into a grid having five rows and four columns. Each of the eight states was randomly chosen and randomly assigned to one of the cells with the restriction that no two states could occupy adjacent cells in the same column or row. In order to increase the complexity of the map, 20 additional boundary lines were added to the map to connect the states and divide up the remaining space. The additional connecting lines and the states were taken from a base map in Reader's Digest Great World Atlas (1963, p. 47). Raised line copies of the map were made using a photoetching process to produce a master plate. Plastic vacuum-formed copies were made from the plates. A photograph of the map is shown in Figure 1.

Insert Figure 1 about here

Training materials. The training materials consisted of three different pseudomaps. Each map was constructed by having different African countries represented on it and were traced from base maps appearing in Goode's World Atlas (Espenshade & Morrison, 1974). Each of the countries was photographically reduced or enlarged to fit within the confines of a 3-inch circle. A 22.86 X 33.02 cm page was divided into a grid having five rows and four columns. African countries were randomly placed in one of the cells with the restriction that no two countries could occupy adjacent cells on the map. Additional boundary lines were added to each map to connect the countries and divide up the remaining space.

Training Map #1 consisted of four African countries which were: Botswania, Libya, Rhodesia, and Somali Republic. Five additional boundary lines taken from the base maps were added to the pseudomap to connect the countries and divide up the remaining space. A photograph of the map is shown in Figure 2.

Insert Figure 2 about here

Training Map #2 consisted of eight African countries which were: Angola, Chad, Ethiopia, Ghana, Kenya, Southwest Africa, Spanish Sahara, and upper Volta. Twenty additional lines taken from the base map were added to the pseudomap to connect the countries and divide up the remaining space. A photograph of the map is shown in Figure 3.

Insert Figure 3 about here

Training Map #3 consisted of eight African countries which were: Algeria, Equatorial Guinea, Gabon, Ivory Coast, Mali, Mauritania, Nigeria, and Zaire. Twenty additional boundary lines taken from the base map were added to the pseudomap to connect the countries and divide up the remaining space. A photograph of the map is shown in Figure 4.

Insert Figure 4 about here

Metal plates of the maps were made using a photoetching process to produce male molds. Vacuum-formed plastic copies were made of each map using the molds.

All the maps used in the study measured 22.86 X 33.02 cm, their lines were raised .051 cm above the surface and were .12 cm in width. All the maps were mounted on cardboard with a nonskid backing. For each of the maps, separate cue cards were made showing each of the states or countries. The states or countries were cut from plastic copies of the maps and each shape was mounted on 8.9 X 8.9 cm cardboard squares with a nonskid backing.

Two shape recognition cards used in Experiment I were also used as training materials.

Design and procedure. All the students were tested with the pretest map. Each student was shown the pretest map for a 1-minute period of free exploration. A subject was then shown a cue card for 30 seconds and asked to locate the shape on the map. The subject was given up to 4 minutes to locate and trace each shape. The cue card remained alongside the map for reference while the subject searched the map. The eight shapes were presented to each subject using the same random order.

At the completion of the pretest, the students were matched in pairs as closely as possible on their accuracy and time scores, respectively. One member of each pair was randomly chosen and assigned to the trained group while the remaining member of the pair was assigned to the control group.

The students in the training condition were trained over a 3-day period in tracing shapes, distinctive features analysis of shapes, and locating shapes on the pseudomaps by locating distinctive features.

Day I: Each student was shown how to trace, pick out distinctive features, and recognize shapes via distinctive features, using two shape recognition cards. Each subject was presented with a standard shape and was shown how to trace by tracing the inside edge of the shape and to pick out three distinctive features on the shape. The card was then flipped over and the subject was asked to locate the correct shape by choosing the shape which had the same parts. If the subject chose the wrong shape, the standard was presented again and the subject repeated the same procedure.

If the subject chose the wrong shape again he was shown the correct choice and told to trace it and pick out the same distinctive features he chose originally. Both cards were presented in the same manner.

After the two cards had been presented the subject was told that he was to locate shapes on a map. The subject was presented with the map which had the four target shapes and given 1 minute to explore the map. He was then shown a cue card and told to trace the inside edge, pick out three distinctive features, trace the shape a second time, and to locate the shape on the map by looking for distinctive features. A subject was given 4 minutes to locate the shape. At the end of 4 minutes the subject was shown the location of the target figure by being shown one of the distinctive features he chose on the cue card and then asked to trace the shape. Assistance was given in tracing if needed. The cue card remained alongside the map during the search period.

Each subject was given 30 minutes for the entire training session. If a subject located all four shapes in less than 30 minutes the map was rotated 180° and he was allowed to locate up to four more shapes or until the 30 minutes was exhausted.

Day II: The subject was reminded about tracing and picking out distinctive features and then given 1 minute to explore one of the pseudomaps having eight shapes. He was then presented with the first cue card and told to trace the inside edge, pick out three distinctive features, trace the shape a second time, and locate the shape on the map. Each subject was given 30 seconds to inspect the cue card and 4 minutes to locate the shape. At the end of 4 minutes the subject was shown the location of the shape if he had not found it. The cue card remained alongside the map during the search period. If time remained, the map was rotated 180° and the subject was permitted to locate up to eight more shapes within the 30 minute time limit.

Day III: Training was the same as Day II except a different map was used.

Beginning on the day after training was completed, the subjects in the trained and control groups were tested with the pretest map which was rotated 180° from its original orientation. The subject was presented with a cue card and told to inspect it for 30 seconds and to locate and trace the same shape on the map. Each subject was given 4 minutes to locate each shape.

Results

The data consisted of the number of shapes located and the mean time required to locate a shape. Separate analyses of variance were computed for each dependent measure. Since subjects in the trained and untrained groups were matched in pairs, this factor was considered as a within subjects factor for purposes of the analysis. Each analysis consisted of a two-factor repeated measures analysis of variance with the factors being pretest vs. posttest and groups (trained vs. untrained). The analysis on the number of shapes located showed that the pretest vs. posttest ($F = 7.33$; $df = 1, 20$; $p < .05$) groups ($F = 11.72$, $df = 1, 20$; $p < .01$) and the interaction of pretest vs. posttest x groups ($F = 11.72$; $df = 1, 20$; $p < .01$) were significant. A summary of the analysis is shown in Table 3. Table 4 shows the means and standard deviations of the number of shapes located on the pre- and posttest for the trained and untrained groups. Because the subjects were matched, the means of the trained and untrained groups were identical (M = 5.29) with nearly identical SD's. Inspection of Table 4 shows that significantly more shapes were located on the posttest by the trained group (M = 6.95) than the untrained group (M = 5.52). This represents a 25.90% improvement by the trained group over the untrained group on the basis of their posttest scores.

Insert Tables 3 & 4 about here

The analysis of variance on the mean time to locate a shape on the map showed that the pretest vs. posttest (F = 14; df = 1, 20; p < .01), groups (F = 8.55; df = 1, 20; p < .01) and the interaction of pretest vs. posttest x groups (F = 9.70; df = 1, 20; p < .01) were significant. A summary of the analysis is shown in Table 5. Table 6 shows the means and standard deviations of the time, in seconds, to locate shapes on the pre- and posttest by the trained and untrained groups. Inspection of Table 6 shows the means and standard deviations of the time scores, in seconds, for the trained and untrained groups were nearly identical on the pretest (trained, M = 135.07, SD = 59.85; untrained, M = 136.36, SD = 60.38). A comparison of the posttest means shows that the trained group significantly reduced the mean time to locate a shape (M = 89.31 sec., SD = 55.05) as compared to the untrained group (M = 125.97 sec., SD = 67.30). This represents a 41% decrease in time by the trained group as compared to the untrained group on the basis of the posttest scores.

Insert Tables 5 & 6 about here

Discussion

Training blind students in line tracing and in a strategy of distinctive features analysis of shapes significantly facilitated their ability and speed of locating and tracing shapes on a map. Coupled with the fact the same type of training facilitated shape recognition performance, it would appear that this method is effective in improving the tactual skills of blind students. However, these studies and their conclusions have their limitations. There is no way of determining which factor(s) of training contributed most to improving performance. These factors are difficult to isolate experimentally because a subject needs to trace an entire figure in order to detect and encode all the distinctive features. Training in tracing the contour line of a shape may implicitly teach the detection of distinctive features and conversely teaching distinctive features analysis may implicitly suggest the necessity for tracing a line. Furthermore, in training both of these skills a subject is learning the derived concept of being systematic. In these studies, the subjects were taught to trace the complete shape in a clockwise direction, taught to pick out a point of departure which was used as a reference point and to perceive the distinctive features in a fixed serial order. It would appear that all these factors are necessary conditions for improving performance in these and similar type tasks.

The training procedures used here are simply applications of Gibson's (1969) concept of distinctive features and Piaget's concept of decentration and perceptual activity (Piaget & Inhelder, 1967, Chap. 1). In addition, emphasis must be given to the principle of serial order which is of critical importance in tactual perception and has been elaborated on by Lashley (1967, pp. 112-136). The tactual perceptual system is the only system of the five major sense systems where the freely roaming hand or finger determines the serial order of perceiving the distinctive features of the stimulus. For visual perception there is a simultaneous perception of the distinctive features and their spatial relationships which are invariant. For auditory events the serial, temporal order of the distinctive features is fixed. In both systems there is relatively little or no room for variation in the serial perception of the distinctive features in comparison to the tactual system. Distinctive features may remain invariant, but in tactual perception the pattern or serial order is subject to wide variation depending on the inspection techniques employed. For example, if a shape had six distinctive features, a child could feel the distinctive features in any one of a possible 720 different sequences. Consequently, the manner in which a tactile stimulus is inspected will determine to a large extent the nature of one's perception. If the same stimulus is presented to the same child on two or more occasions, the inspection strategy could well contribute to whether the child perceives the two stimulus events as being identical or different.

This analysis suggests the importance of teaching blind children to be analytical, systematic, and complete in exploring their immediate tactile environment which would facilitate the development of other perceptual abilities and concepts which, of necessity, must be acquired through the tactual system.

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Footnotes

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Table 1

Analysis of Variance of Percentage of Correct Shape Recognitions for Trained vs. Untrained Subjects on the Pretest and Posttest

Source	SS	df	MS	F
Total	39,309.36	99		
Trained vs. untrained (groups)	1,369.00	1	1,369.00	21.20**
Pretest vs. posttest (tests)	772.84	1	772.84	6.54*
Groups x tests	1,128.96	1	1,128.96	27.66**
Subjects	30,672.86	24		
Groups x subjects	1,549.50	24	64.56	
Tests x subjects	2,836.66	24	118.19	
Groups x tests x subjects	979.54	24	40.81	

*$p < .05$

**$p < .01$

Table 2

Means and Standard Deviations for Percentage of Correct Shape Recognitions of Trained and Untrained Subjects

	Pretest	Posttest
Trained	*M* = 45.64 *SD* = 17.23 *n* = 25	*M* = 57.92 *SD* = 21.16 *n* = 25
Untrained	*M* = 44.96 *SD* = 17.79 *n* = 25	*M* = 43.80 *SD* = 20.98 *n* = 25

Table 3

Analysis of Variance on Number of Target Areas Located as a Function of Training vs. No Training and Pretest vs. Posttest

Source	SS	df	MS	F
Total	483.24	83		
Trained vs. untrained (groups)	10.71	1	10.71	11.72**
Pretest vs. posttest (tests)	19.05	1	19.05	7.33*
Groups x tests	10.71	1	10.71	11.72**
Subjects	354.24	20		
Groups x subjects	18.29	20	.91	
Tests x subjects	51.95	20	2.60	
Groups x tests x subjects	18.29	20	.91	

* $p < .05$

** $p < .01$

Table 4

Means and Standard Deviations of Number of Target Areas Located as a Function of Training vs. No Training and Pretest vs. Posttest

Group	Pretest	Posttest	Total
Trained	*M* = 5.29 *SD* = 2.55 *n* = 21	*M* = 6.95 *SD* = 1.72 *n* = 21	*M* = 6.12 *SD* = 2.31 *n* = 21
Untrained	*M* = 5.29 *SD* = 2.55 *n* = 21	*M* = 5.52 *SD* = 2.48 *n* = 21	*M* = 5.40 *SD* = 2.49 *n* = 21
Total	*M* = 5.29 *SD* = 2.52 *n* = 42	*M* = 6.24 *SD* = 2.23 *n* = 42	

Table 5

Analysis of Variance on Mean Task Time to Locate Target Areas as a Function of Training vs. No Training and Pretest vs. Posttest

Source	*SS*	*df*	*MS*	*F*
Total	326,414.18	83		
Trained vs. untrained (groups)	7,562.77	1	7,562.77	8.55*
Pretest vs. posttest (tests)	16,554.84	1	16,554.84	14.00*
Groups x tests	6,568.12	1	6,568.12	9.70*
Subjects	240,834.60	20		
Groups x subjects	17,696.78	20	884.84	
Tests x subjects	23,651.75	20	1,182.59	
Groups x tests x subjects	13,545.32	20	677.27	

* $p < .01$

Table 6

Means and Standard Deviations of Mean Task Times to Locate Target Areas as a Function of Training vs. No Training and Pretest vs. Posttest

Group	Pretest	Posttest	Total
Trained	*M* = 135.07 *SD* = 59.85 *n* = 21	*M* = 89.31 *SD* = 55.05 *n* = 21	*M* = 112.19 *SD* = 61.33 *n* = 21
Untrained	*M* = 136.36 *SD* = 60.38 *n* = 21	*M* = 125.97 *SD* = 67.30 *n* = 21	*M* = 131.16 *SD* = 63.37 *n* = 21
Total	*M* = 135.71 *SD* = 59.38 *n* = 42	*M* = 107.64 *SD* = 63.50 *n* = 42	

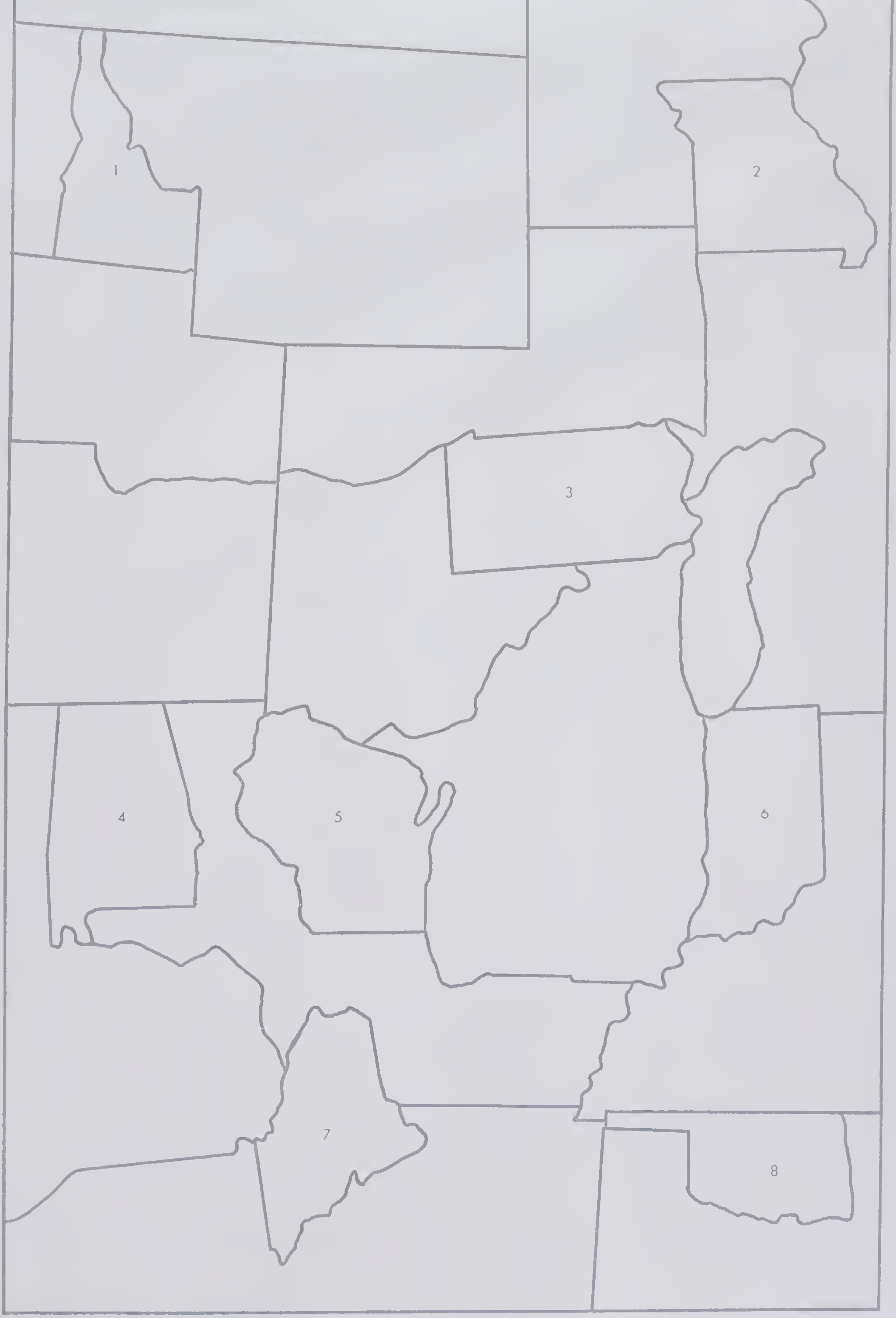
Figure Captions

Figure 1. The pre-posttest map consisted of eight states of the United States randomly placed on the map. Twenty additional lines were added to connect the states and divide up the remaining space. The size of the map was 22.86 X 33.02 cm. The lines were raised .051 cm above the surface and were .12 cm wide. The shapes were numbered for identification purposes with ink.

Figure 2. Training Map #1 consisted of four African countries randomly placed on the map. Five additional lines were added to connect the countries and divide up the remaining space. The size of the map was 22.86 X 33.02 cm. The lines were raised .051 cm above the surface and were .12 cm wide. The shapes were numbered for identification purposes with ink.

Figure 3. Training Map #2 consisted of eight African countries randomly placed on the map. Twenty additional lines were added to connect the countries and divide up the remaining space. The size of the map was 22.86 X 33.02 cm. The lines were raised .051 cm above the surface and were .12 cm wide. The shapes were numbered for identification purposes with ink.

Figure 4. Training Map #3 consisted of eight African countries randomly placed on the map. Twenty additional lines were added to connect the states and divide up the remaining space. The size of the map was 22.86 X 33.02 cm. The lines were raised .051 cm above the surface and were .12 cm wide. The shapes were numbered for identification purposes with ink.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